Ray tracing computations in the smoothed SEG/EAGE Salt Model, Part 3: Maps of reflections

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Summary

The paper presents computation of two-point rays of the P-wave reflected from the flat bottom interface in the smoothed SEG/EAGE Salt Model. Six shot-receiver configurations derived from the original Phase A Acquisition are used for generation of reflection point maps, colour coded according to amplitudes.

Keywords

Velocity model, ray tracing, seismic waves, reflection maps

1 Introduction

There is an interest to find reflectors below the salt bodies. High velocity contrast and various complex shapes of the salt bodies cause shadows zones below salt where little energy is reflected. Ray tracing is the method used to model and study such situations with respect to real field seismic measurements (Muerdter et al. 1998, Bear et al. 2000, Muerdter et al. 2001abc).

This paper shows the application of the SW3D software to the construction of reflection maps in the smoothed SEG/EAGE Salt Model. To study the subsalt area two-point rays of P-wave reflected from the bottom flat interface for six shot-receiver configurations are computed. Reflection points colour coded according to amplitudes are generated and plotted. The smoothed SEG/EAGE Salt Model (Bulant 2001, 2002, 2003) with the most important interfaces (ocean bottom, interfaces limiting the salt body, geopressure horizon, bottom flat interface) is the same as in the first and second papers (Bucha 2003, 2004). For short description of the model see the first paper (Bucha 2003).

Files referred in this paper and used for computation are included on compact disk SW3D-CD-8 (Bucha & Bulant 2004) in packages CRT, MODEL, FORMS and DATA. The GOCAD program is used for visualization of the 3-D smoothed Salt Model with interfaces, shots, receivers, computed two-point rays and maps of reflections. The figures in the paper are GOCAD screen snapshots of limited resolution. All computations were performed on a PC equipped with Athlon XP 1700+ processor and with Linux operating system.

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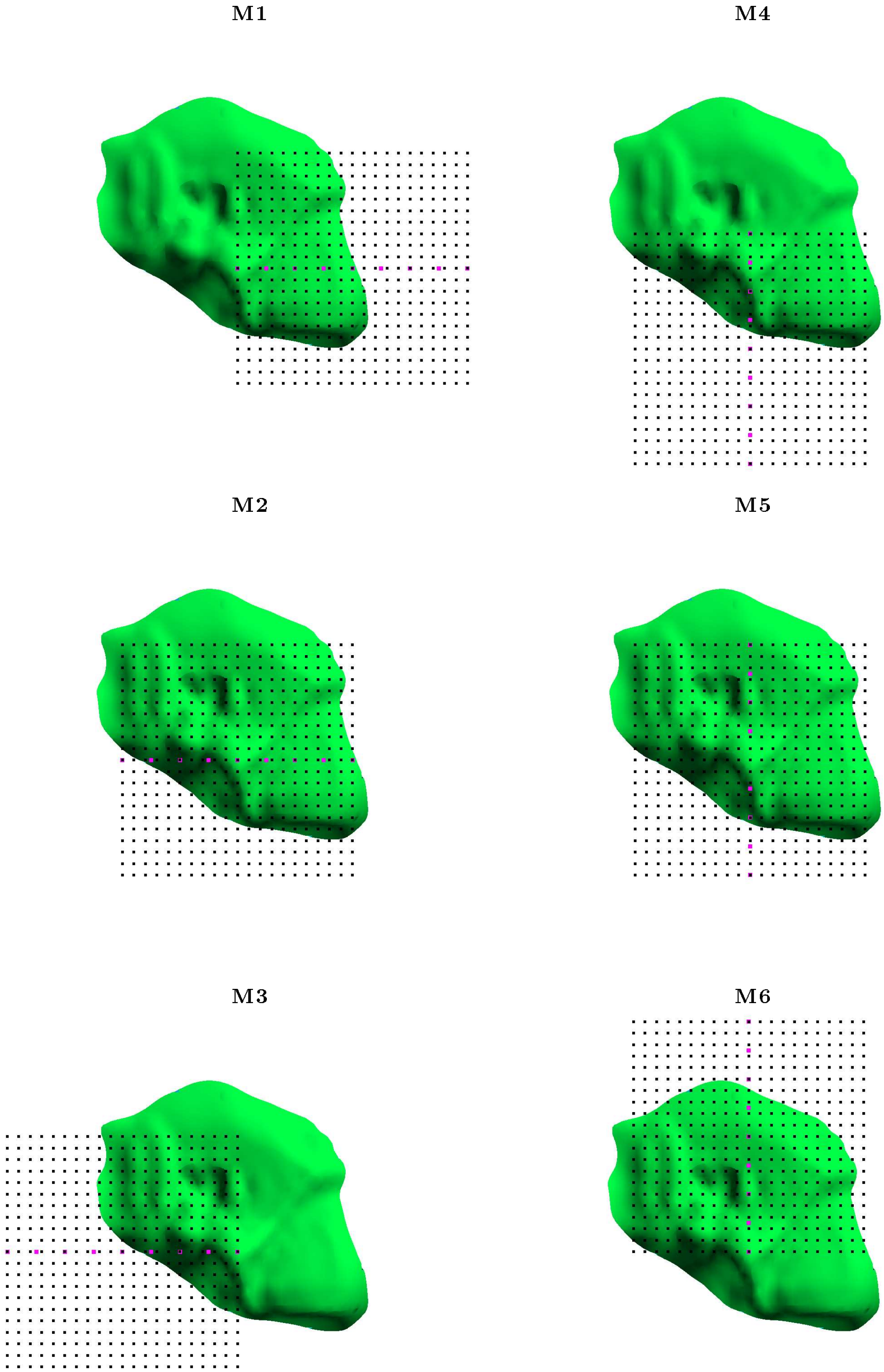

Figure 1. Top view of six shot-receiver configurations M1,...,M6 and salt body. Magenta points represent positions of shots.

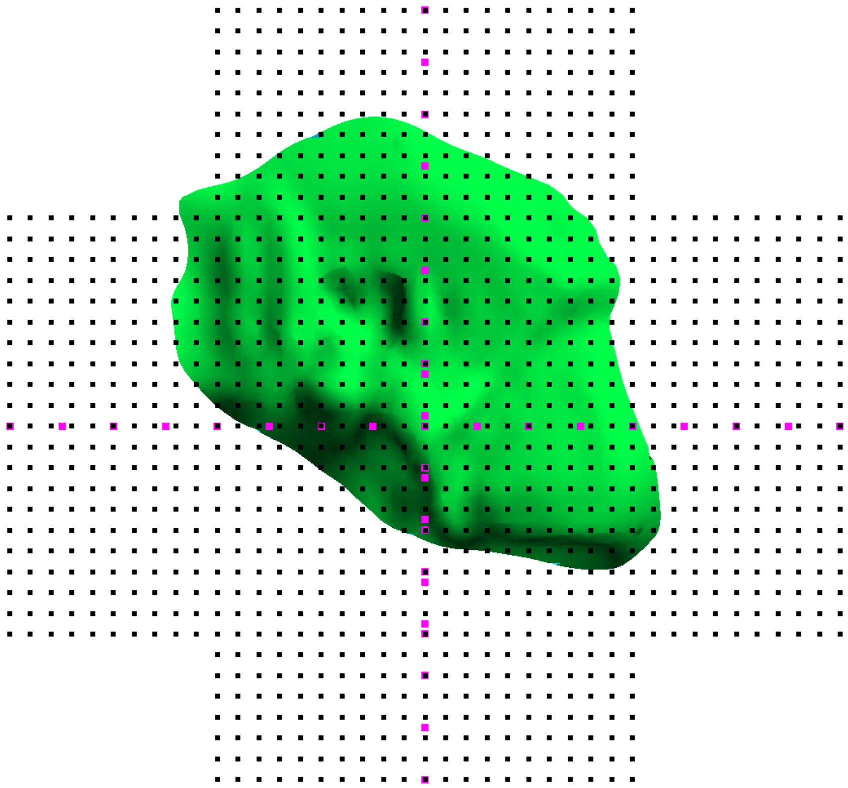

Figure 2. Top view of all shots, receivers and salt body.

2 Shots and receivers

The position of the shots and receivers is derived from the original SEG/EAGE Phase A Acquisition (Aminzadeh *et al.* 1997). Figures 1 and 2 show six shot-receiver configurations used for calculation of two-point rays.

The basic configuration is the square of 21x21 receivers with the centre above the crest of the salt (configurations M2 and M5 on Figure 1). This square of receivers is used for computations in two previous papers (Bucha 2003, 2004). The square of receivers and sources is shifted by the half of the square side to right, left and towards the top of the paper (see Figures 1 and 2). The shift of receivers towards the bottom of the paper was smaller than half of the square side because of the boundary of the model. The receivers are located in the depth of 0m and the grid step is 320m. The names and coordinates of receivers are specified in files `sal-rec1.dat`, `sal-rec4.dat`, `sal-rec6.dat`, `sal-rec7.dat`, `sal-rec9.dat`. There are 9 shots for each configuration with one exception for the central configuration M5 with only 8 shots (the central shot is not duplicated). Shots are located in the depth of 20m and the step is 800m. The names and coordinates of shots are specified in files `sal-src4.dat`,...,`sal-src9.dat`.

3 Ray tracing computations

History file `sal-mapx.h` manages the computations for all six shot-receiver configurations. This history file executes step by step six other history files `sal-map1.h`,..., `sal-map6.h`. All of these six history files can be executed separately.

The history files contain both the data and the information how to execute the programs. Detailed description of the use of history files can be found in older report papers, e.g., Bulant & Klimeš (1998), Bucha (2001). In this paper only short description of the computation steps will be presented.

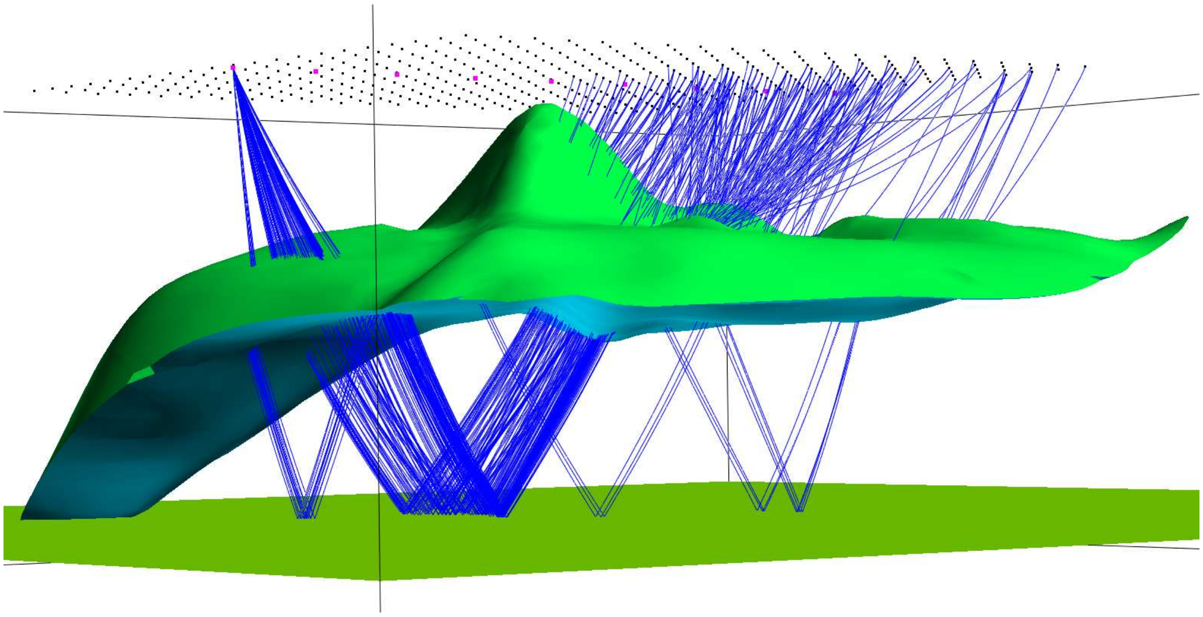

Figure 3. Rays of the P-wave reflected from the bottom flat interface. Interfaces are coloured according to the indices of surfaces.

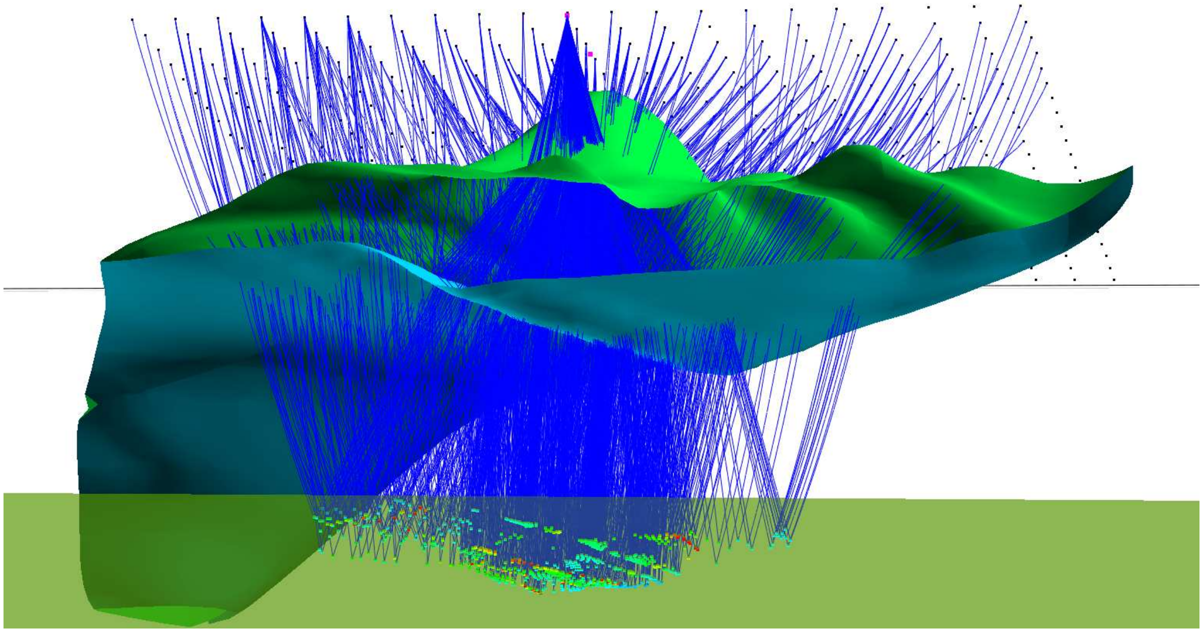

Figure 4. Rays and reflection points colour coded according to amplitude. Bottom flat interface is partially transparent and the model is cut by GOCAD slicer to see the raypaths in salt body.

The first and the most time consuming step of each history file is the complete ray tracing (program `crt.for`). Two-parametric shooting method is used for two-point ray tracing. The twelve codes of elementary waves are defined in the file `sal-cod4.dat`.

Data for ray parameters are specified in file `sal-rpa4.dat`. Ray tracing output files are then processed. Program `rpplot.for` plots ray parameters into a PostScript file. Program `crtray.for` converts the unformatted output of program `crt.for` into formatted files with rays suitable for plotting. Program `linwrl.for` adds rays of computed waves into GOCAD files. Program `ptswrl.for` does the same for maps of reflection points, shots and receivers.

Figures 3, 4 and 5 show rays of computed waves. The figures are screen snapshots of several GOCAD camera positions with limited resolution. Some of the interfaces are partially transparent and cut by GOCAD slicer. The possibility to generate VRML files is not used because known VRML browsers cannot switch on and off displayed objects, especially computed rays and the visualization of all rays at once is not very reasonable.

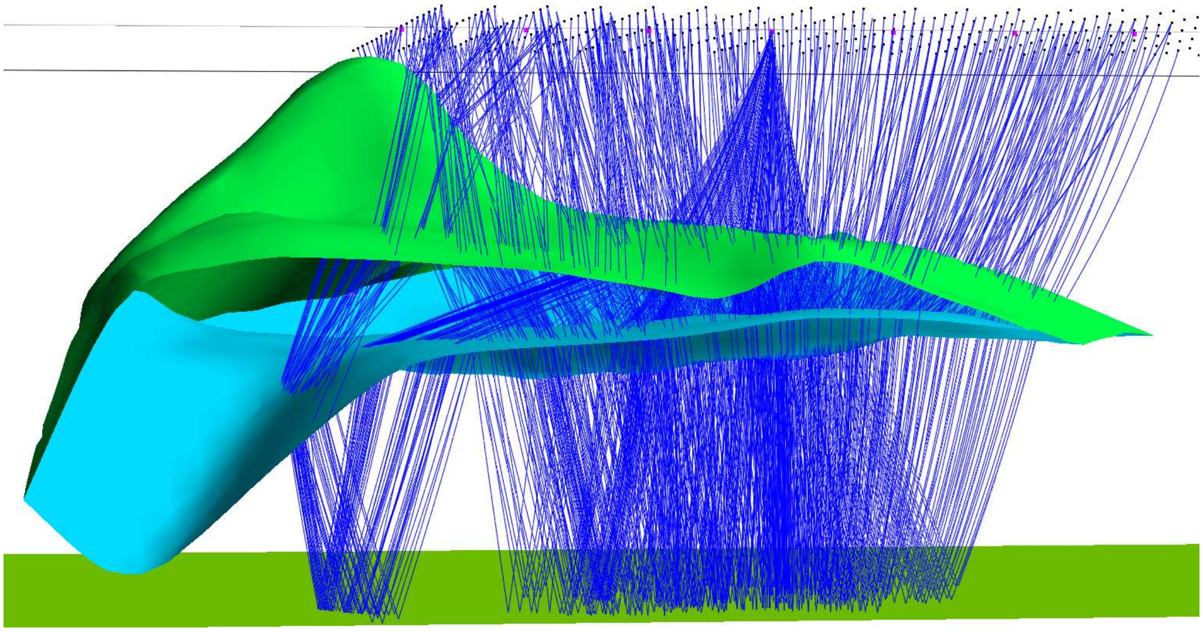

Figure 5. Rays of the P-wave reflected from the bottom flat interface. The model is cut by GOCAD slicer.

4 Maps of reflections

Two-point rays of P-waves reflected from the bottom flat interface for six shot-receiver configurations (53 shots, 2646 receivers) are computed. Figures 6, 7 and 8 show reflection points colour coded according to the reflection amplitude. The distribution and amplitude of reflection points are affected mainly by the salt body shape, velocity properties and shot receiver configuration. Reflection maps show areas with strong and dense reflections below the salt crest and reflection shadows below the "trunk" of the salt body and the trough on the bottom interface of the salt body. The raypaths are in many cases complicated (see Figures 3 and 5), therefore displaying of reflection points and two-point rays for each shot and each elementary wave separately is recommended for detailed study of subsalt reflections (see Figure 4).

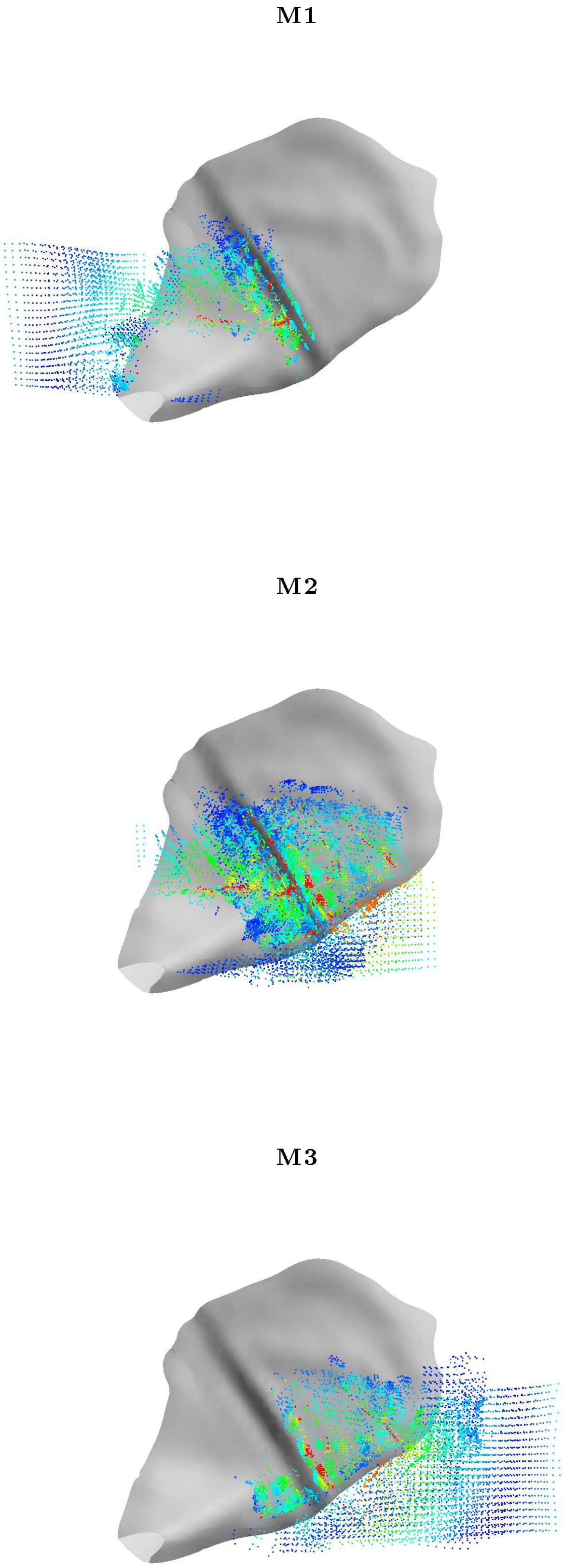

Figure 6. Bottom view of six maps of reflections and salt body.

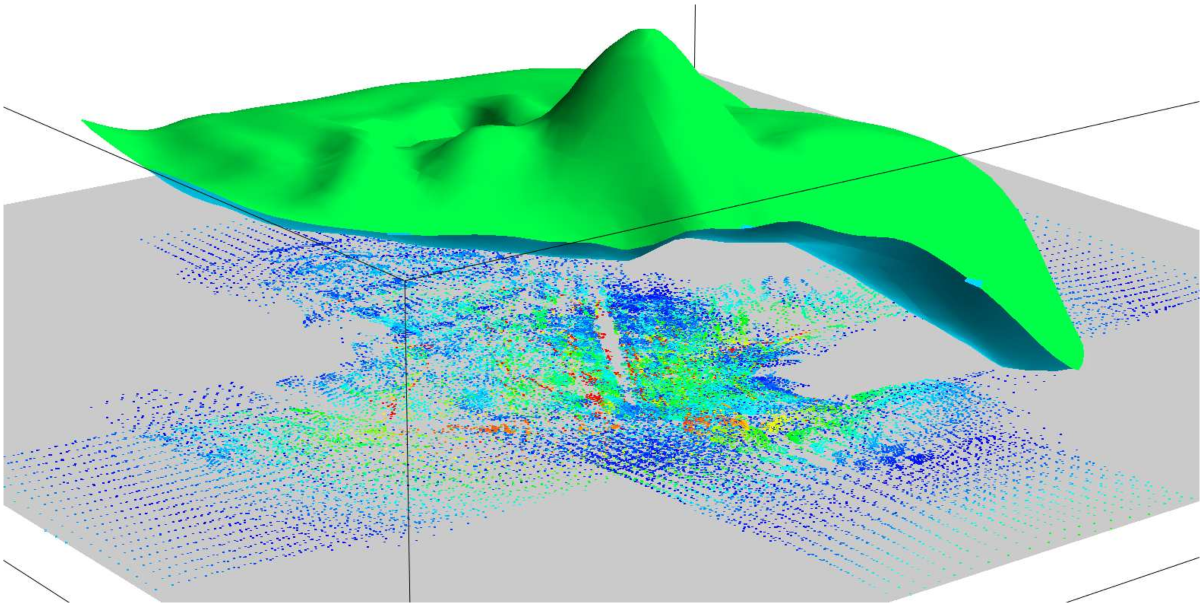

Figure 7. Map of all reflection points, colour coded according to amplitude, and the salt body.

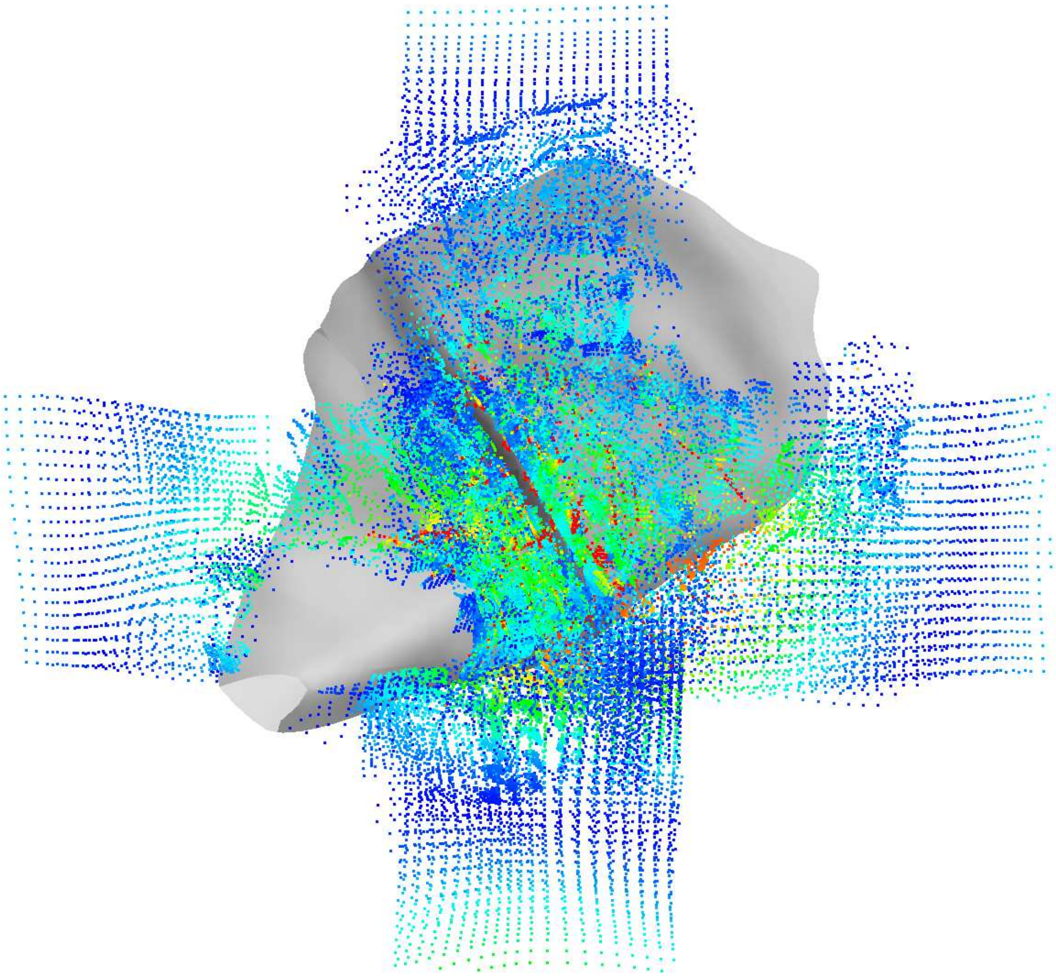

Figure 8. Bottom view of map of all reflections.

5 Conclusions

Results of the calculations using SW3D software show that the smoothed Salt Model is suitable for two-point ray tracing. Computation and visualization of rays and maps of reflections of individual elementary waves is a great advantage of ray tracing method and should help to study problems in subsalt areas. Reflection maps on the bottom flat interface show areas with strong and dense reflections and reflection shadows.

The time of the whole computation of the history file `sal-mapx.h` was approximately 62 hours on a PC equipped with processor Athlon XP 1700+ and with Linux operating system.

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